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PREVIEW

PRESIDENT KARL TAYLOR COMPTON contributes "Three Adventures in Physics" to this issue of TECH ENGINEERING NEWS. A nationally known physicist in his own right, Doctor Compton is more than well able to discuss what he considers to be "The most active fields in experimentation and theory in physics of the last two or three years." The article treats of the transmutation of chemical elements, the mystery of the cosmic rays, and the new developments in high voltage apparatus from which so much new knowledge is expected. Doctor Compton cleverly relates these subjects to their effect on human affairs, thus greatly adding to the popular interest already shown in them.

ROCKET travel, long discussed both within scientific circles and out of them, is another subject just now very much before the public eye. Cecil E. Mann, a sophomore, describes the principle upon which rocket motors operate and outlines both the present status of their development, and the probability of their practical use in the near future. The possibility of high speed long distance travel which the rocket offers is sufficient to stir the imagination of even the most disillusioned design engineer.

THE growing use of solid carbon dioxide, known commercially as "Dry Ice," for all refrigeration problems is bringing it before the engineering profession with increased emphasis. Alonzo W. Ruff, of the Class of '26, who has been engaged in developing dry ice machinery since his graduation, describes its properties and manufacture on a commercial scale. The ingenious methods by which dry ice is used in controlled-temperature systems is worthy of the attention of every engineer.

THE appearance and general performance of the autogiro are well known to everyone, but the principles of its design, and the particular problems which must be overcome by the designing engineer in planning the machine, have not been adequately dealt with. Mr. Harris S. Campbell, a member of the engineering staff of the foremost autogiro concern, aptly describes the details of the Flying Whirligig in a way interesting even to the lay reader.

SAMUEL A. LEWISOHN, a leader in the industrial life of this country, contributes the concluding installment of his discussion of the relations between the engineer and the labor he uses. The success of those engineers who show themselves able to control large groups of subordinates should encourage those entering the profession to study the methods by which executive leaders handle the labor problem. Mr. Lewisohn, drawing on his large and varied experience, is well able to advise the undergraduate and the young engineer in the problems they will meet as their executive responsibilities increase.

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FLAME AND IRON

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XIII OCTOBER, 1932 NUMBER 5

THREE ADVENTURES IN PHYSICS

Transmutation, Cosmic Rays, and High Voltage

By KARL TAYLOR COMPTON
President, Massachusetts Institute of Technology

IN their long search for the inner secret of the atom and the key to unlock its energy, physicists of the present generation have had amazingly unexpected adventures. Starting with the statistical atoms and molecules of the chemists, they have found the individual atoms, have discovered the electron, proton and photon, have found out exactly what each atom is made of, have made great progress in explaining the physical and chemical properties of matter, but have only begun to uncover the *innermost* secrets of the atomic energy which resides in its nucleus. They have gone far enough to realize that these are mighty secrets, probably involving the origin and fate of the universe as well as sources of energy far exceeding any as yet under man's control. This search has led out of the laboratory to the cosmic ray expeditions of Millikan and A. H. Compton, to the balloon ascents of Piccard into the stratosphere and to the giant high-voltage generator of Van de Graaff. A brief outline of the significance of this work is particularly appropriate in an M. I. T. publication, since Professor Bennett of the Electrical Engineering Department headed one of Compton's cosmic ray parties this summer and Dr. Van de Graaff, a member of the Physics Department, is building his generator in the huge new high-voltage laboratory made available at Round Hill by the generosity of Colonel E. H. R. Green.

Transmutation

When Lord Rutherford showed that the phenomena of radioactivity are the external manifestations of spontaneous transmutation of chemical elements, the age-old dream of the alchemists appeared about to be realized. But alas, no way of controlling or accelerating these changes has been found. The energy released in these atomic changes is so great, however, that wonderful things could be done with it if some way could be found to release it, at will, as rapidly as desired. Radium, for example, gives out every hour enough energy to raise its same weight of water from freezing to boiling temperatures and keeps this up for two thousand years.

This energy resides in three types of radiations: electrons (beta particles), doubly charged helium atoms (alpha particles) and aether waves (gamma rays). These are all ejected from the nuclei of atoms, and the ejection of either an alpha or a beta particle leaves the nucleus with a different electric charge, and hence as a different kind of atom. These alpha and beta particles are ejected with speeds up to within a few per cent of the speed of light. The gamma rays have shorter wavelengths than any radiation hitherto known.

It is not quite true that scientists have been entirely unsuccessful in their attempts artificially to cause atomic transmutations. About ten years ago Rutherford showed that hydrogen nuclei (protons) could be knocked out of several kinds of atoms if these were bombarded by fast alpha particles. In some of these cases the kinetic energy of the liberated proton was much greater than that of the bombarding alpha particle. This might suggest that we have here a source of great energy at our command, but such hope is dashed by the fact that the process is hopelessly inefficient, only about one in six hundred thousand of the bombarding particles striking so as to cause such an energetic transmutation.

About three years ago Van de Graaff predicted, and six months ago two Cambridge physicists experimentally discovered, a new type of atomic transmutation which involves a synthesis rather than a disintegration of atoms, and which is effected with the aid of high voltage. Protons, accelerated by several hundred thousand volts, bombard a target of lithium and cause emission of pairs of alpha particles with energies of about fifteen million volts! This and other recent discoveries suggest

that we may really be only on the edge of a virgin field of exploration of sub-atomic energies.

Cosmic Rays

Atmospheric air is always slightly conducting to electricity, which means that it is to a small extent ionized. For a generation this ionization had been attributed to known traces of radioactive materials which permeate the earth and atmosphere. Now all radioactive radiations are absorbable to experimentally known extents by matter. Thus the fastest alpha particles will traverse only 11 cm. of air; the fastest beta particles are two-thirds absorbed by 0.1 cm. of aluminum; and the most penetrating gamma rays are two-thirds absorbed by 2 cm. of lead. For some years, however, there has been evidence of naturally occurring ionizing radiations, of unknown origin, which are considerably more penetrating than any of these radioactive radiations.

The first clue to the source of these ultra-penetrating radiations was obtained by Korlhörster who sent up recording ionization apparatus in balloons and discovered unexpectedly intense ionization at very great altitudes, both day and night. Millikan and his associates, in extending these observations, developed a very clever precision method of measuring the penetration of these rays in matter. They submerged the ionization apparatus in deep, snow-fed mountain lakes, in order to measure the intensity of the rays at various depths. Lakes at high altitudes were preferred in order to eliminate as far as practicable the disturbing effects of the earth's atmosphere, and spring-fed lakes were avoided since their waters would be contaminated with radioactive salts in solution, which would cause complicating additional ionization.

These experiments showed that the cosmic rays are not homogeneous, *i.e.*, that they have something like a "spectrum" of rays of differing penetrating powers. They showed also that the rays come approximately equally from all directions in space. Their enormous penetration, as compared with the most penetrating previously known radiation, gamma rays, is shown by the fact that they are still appreciable after penetrating 200 feet of water, which would be equivalent to 18 feet of lead or six times through the earth's atmosphere!

Analogy with other known forms of penetrating rays leads us to suspect that cosmic rays are aether waves, of wavelength far shorter even than gamma rays, or that they are electrons with terrific speeds. Millikan holds the former view and attempts to estimate their wavelength from their penetrating power, by extrapolating the curve of wavelength *vs.* penetration which is known experimentally throughout the x-ray and gamma ray region. Admittedly this extrapolation is not very accurate, since it involves a tenfold extrapolation aided by a rather speculative formula. Some German physicists, on the other hand, hold to the view that cosmic rays are high-speed electrons. Several physicists have also suggested that cosmic rays are neutrons, an hypothetical type of particle logically to be expected but almost impossible to detect or study because of the peculiarity that it would be devoid of all chemical and practically all physical properties.

One property should distinguish between electrons, on the one hand, and aether waves or neutrons on the other: the former should be deflected by the earth's magnetic field and concentrated near the earth's magnetic poles. To test this possibility was the principal objective of the five cosmic ray expeditions organized by Prof. A. H. Compton under the auspices of the Carnegie Institution of Washington. These expeditions have actually found the intensity of ionization by cosmic rays to increase progressively from the equator to the poles. This does not, however, *prove* the primary cosmic rays to be electrons, for the electrons indicated by these experiments may simply be the products of ionization of material in the upper atmosphere or even in interplanetary space which have been projected forward at high speeds by the cosmic rays in the act of ionization.

However these things may be, the cosmic rays are evidence of subatomic energy changes of even greater magnitude than those involved in radioactivity or other recognized types of atomic transmutation! To what can such enormous energies be due and what is their nature?

Einstein

The answer to this question is believed to lie in two equations, both products of Einstein's genius:

$$E = mc^2 \qquad (1)$$
$$E = h\nu = eV \qquad (2)$$

Simple as they appear, these equations are the foundation of atomic physics.

Equation (1) expresses the equivalence of energy E and mass m in terms of the velocity of light c. According to it, any change of energy is accompanied by a change of mass, or vice versa. In chemical reactions, the accompanying mass change is undetectably small. For example, in the burning of coal the decrease in mass would be only seven millionths of one per cent — far too little to be detected experimentally. Stated otherwise, equation (1) means that 2.13 $(10)^{13}$ calories of energy are liberated for every gram of matter which vanishes.

We know that mass vanishes in atomic transmutations since, although all atoms are built up out of

(*Continued on page 97*)

George Washington Bridge

The Studebaker Wheel

Rocket Travel—
A TRANSPORTATION PROBLEM
Worth Solving

By CECIL E. MANN '35

THE magic of possible rocket flights into the vast void of space has long appealed to writers of fiction. Doubtless all readers are familiar with the conception of such a flight by Jules Verne, in which his voyagers are comfortably settled within a huge hollow projectile and then shot from a gigantic cannon imbedded in the earth. Perhaps not so familiar is that fantasy by Poe in which a gigantic balloon filled with a gas thirty-seven times lighter than hydrogen was utilized. In his story Poe suggested the remarkable theory that as the balloon rose and the density of the atmosphere decreased, the air resistance would also decrease and therefore the balloon must rise with an ever-increasing velocity!

INTERPLANETARY MARKS FOR ROCKETS TO REACH

Planet	*Distance from Earth*	*Gravitational Pull*
Mercury	47,229,000 miles	14.9 ft./sec.^{2}
Venus	23,309,000	28.1
Mars	33,375,000	9.76
Jupiter	359,817,000	79.78
Saturn	730,198,000	35.18
Uranus	1,579,035,000	23.42
Neptune	2,629,359,000	25.24
Earth	.....	32.16

Today actual rocket travel is rapidly becoming one of the probabilities of the immediate future. Nearly all research work looking toward actual travel has been carried out within the twentieth century. As early as 1912 theoretical data were being collected by Dr. R. H. Goddard, now the foremost rocket authority in America, and by the year 1915 he was carrying on actual experiments. During the World War some experiments were carried out in connection with their use in warfare, but little was accomplished. At the present time at least seven countries are engaged in rocket research, with Germany and the United States well in the lead.

Practical uses for the rocket are not many at the present time. Possibly its greatest value would be as a means for determining various scientific data concerning the upper atmosphere. Although the earth's atmosphere extends for nearly 230 miles, little is known about the region above 20 miles, which is the altitude to which sounding balloons may rise. Of course various theories are in evidence regarding the composition of these upper regions, and the one most generally accepted is the following: the atmosphere is divided into four concentric spheres. The first, or troposphere, includes the cloud layer. Above that is the stratosphere, which consists principally of nitrogen, and beyond that a third sphere composed of hydrogen. The fourth and outermost sphere, beginning somewhere around 100 to 120 miles out, is known as the geocoronium sphere. Geocoronium is an element undiscovered at the earth's surface, but is the principal, if not the sole, constituent of the earth's outer atmosphere. Its spectrum line has been found, and the gas itself is believed to have only 0.4 the weight of hydrogen. The rocket would be invaluable as an aid in determining the accuracy of these conclusions. A second and more practical use for the rocket would be for transoceanic travel. However, there are several obstacles yet to this use, which will be discussed later.

The reasons why the rocket alone offers a practical means of penetrating the ether are easily understood when one considers the following facts. As a rocket travels, the only forces which oppose its motion are the air-resistance and the attraction of the earth. If temporarily these forces are neglected it can be said that the rocket is an isolated system of forces, or in other words, the escaping gases, as they leave the rocket, provide it with a forward momentum equal to that which they possess, and it is this which causes the rocket to operate.

By considering separately several factors which enter the exact calculation of the rocket's motion, it is possible to avoid complicated formulæ. A statement of the velocity of escaping gas is that it is equal to the square root of twice the pressure difference within and without the rocket divided by the density of the escaping gases. As the rocket penetrates farther and farther into the atmosphere, the exterior pressure becomes less and less, thus increasing the pressure difference. Also the air resistance which opposes the motion is decreasing, as is the gravitational pull of the earth. We find further that the momentum per second of the escaping gases depends upon their velocity, the pressure difference, and the size of the gas outlet. As before stated, this momentum is equal and opposite to that of the rocket. Another factor to be considered, therefore, is the mass of the rocket. The length of the rocket is immaterial, as "skin friction" is negligible, but calculations, as carried out by Dr. Goddard, have shown that the cross section of the rocket should be proportional to the two-thirds power of the mass of the rocket at any instant. Of course, that is the ideal condition, impossible from a practical standpoint. So far, the nearest approach to this condition is to have the rocket built in sections and as the fuel is used from a section, to release it from the rocket and reduce the cross section in that manner. This device also serves to cut down the mass of the rocket as it soars through space.

The fuel utilized by early experimenters consisted of smokeless powder, but this proved extremely unsatisfactory, since no practical manner could be devised for controlling the rate of consumption. Then experimenters conceived the idea of using a liquid fuel, such as some hydrocarbon, combined with liquid oxygen. It is supposed that the first attempt to use such a fuel

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Inventive Talent in
THE MANUFACTURE OF SOLID CO_2
Builds a New Industry

By ALONZO W. RUFF '26
Developing Engineer
York Ice Machinery Corporation

THE Dry Ice Industry is one of many to have established a solid foothold during the recent period of prosperity. Like any new undertaking of this nature, it has been confronted with innumerable problems in respect to manufacture, distribution and application of its product. Even though a sizable market has already been established, it is yet necessary to standardize prices and engineering practice. The product itself is interesting in its properties and peculiarities. Although it is accepted whole-heartedly by the ice cream and several food product industries, applications and means of transportation are yet to be refined and understood before general acceptance and use can be realized. The possibilities for inventive talent are so obvious to those familiar with Dry Ice that it never fails to arouse the engineer's enthusiasm.

The process of producing Dry Ice is physical, in that carbon dioxide gas or liquid is changed in state to a solid by extraction of heat. Usually, the gas is passed through several compression stages with suitable heat exchangers and condensers. The resultant subcooled liquid is expanded through a nozzle to atmospheric pressure, whereby it cools itself by evaporation, to a point in temperature and pressure which produces a solid in the form of fine crystals together with some gas. The gas is returned for recompression while the solid is collected in a press and packed into blocks. These blocks are usually in the form of cubes, 10 inches on a side, weighing about 50 pounds.

An alternate method is to freeze the liquid by evaporation below the triple point and thus have it solidify in a mould, which later can be opened to atmospheric pressure. The relative qualities of either process are an open question. However, most of the product on the market today is manufactured by the expanding nozzle apparatus.

The carbon dioxide gas can be produced by burning coke, or taken as a by-product from many chemical processes. With any method, it is imperative that the CO_2 be purified of moisture, odorous and corrosive fumes, since the Dry Ice will often be used in direct contact with food products.

Dry Ice, like liquid air, is only stable if protected from heat sources. It has a subliming temperature of −109 degrees F. under atmospheric pressure, which means that very good insulation against heat leakage through the container walls is necessary, when it is held in storage. However, the gas produced by sublimation is a very good insulator in itself and so insures very low convection and conduction surface coefficients.

The gas is heavier than air and therefore tends to drop. Illustrating this point, if Dry Ice is placed in a bucket, the CO_2 gas will fill the bucket and flow over the edge in a dense cloud. This characteristic in combination with the drying effect of the gas, makes it more economical to use a top opening storage chamber.

Concentrated carbon dioxide gas has no distinctive odor, but produces a prickly sensation in the nostrils. When the gas is cold, this sensation seems even more pronounced. Several deep breaths cause a dizzy sensation, which often results in a slight headache. Under normal conditions, these effects will not be noticed, but it is always well to spill out the gas before entering large storage vaults. In designing refrigerating units, it is good practice to direct the gas into the insulation, or to the outside directly from the Dry Ice container.

No insulation is perfect, so that there is a constant loss while in storage, due to heat infiltration and consequent escape of the evolved gas from sublimation. In addition to this difficulty, the cakes of solid tend to crumble or "sugar," a change which is probably due to gradual enlargement of crystal size. This process usually starts in the center of the cake, working outward. Storage losses in both weight and quality have taught the consumer to order in small quantities and the producer to refrain from long shipments and extended periods of storage. Experience has shown that the sublimation losses are much less if the Dry Ice is stored in large cakes, thus reducing the exposed surface. Also

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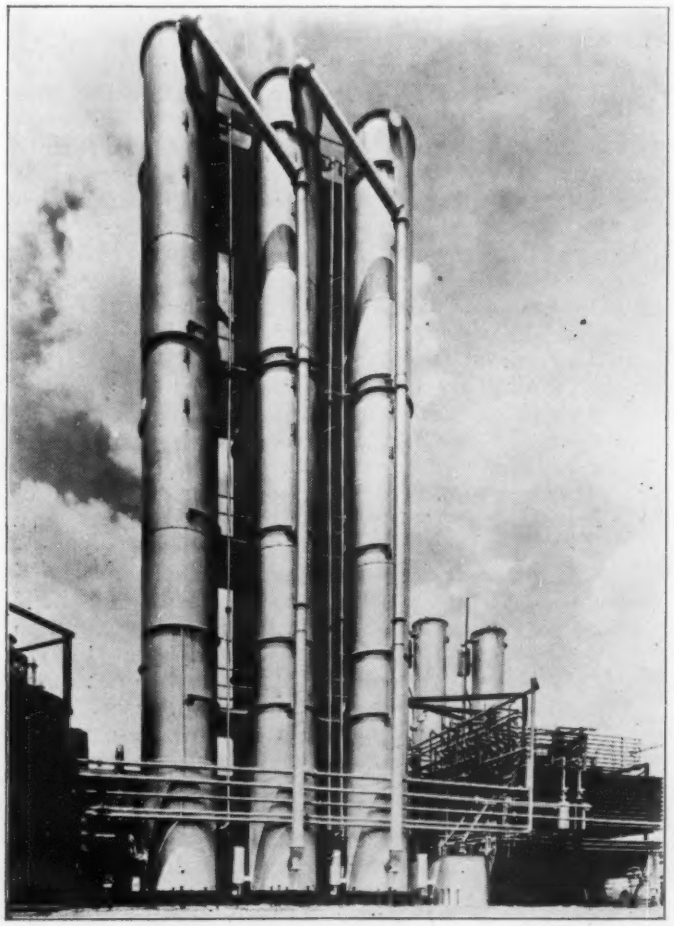

Technology Review

CO_2 Absorbing Towers of a Dry Ice Plant

Aeronautical

ENGINEERING IN THE AUTOGIRO
—*Its Design Features*

By HARRIS S. CAMPBELL
Design Engineer
Autogiro Company of America

THE Autogiro's ability to land and take-off in restricted areas and its safety during flight because of its non-stalling and non-spinning characteristics are well known. It is capable of very slow speed flight as well as high speed. In the event of a forced landing, the Autogiro can be brought down safely and landed without forward run in a small space. In bumpy air conditions the flexible sustaining rotor acts as a shock-absorbing medium and provides improved riding qualities.

These unique qualities of the Autogiro find their origin in the rotor. The rotor consists basically of four blades or wings, pivotally fastened to a rotating hub structure. The first Autogiros which flew used only a horizontal blade-pivot. This simple blade connection was the means of attaining successful flight on rotative wings, as the problems of gyroscopic force and dissymmetry of lift were thus eliminated. In addition, hinging the blades eliminated the major bending moments, making possible the use of a light flexible blade construction with freely jointed blades. It might be expected that a sharp maneuver would cause the body of the craft to move before the blades would respond. However, a change in attitude of the body gives a corresponding change to the rotor axis, thus altering the angle of incidence of those blades of the rotor which are for the instant at an angle to the direction of roll or pitch. These blades then are instantly acted upon by strong aerodynamic and centrifugal forces, causing the blades to maintain their normal relationship with the axis of rotation. No lag of the rotor during maneuvers can be detected either by the eye or by slow-motion camera. Improved rotor construction included a vertical pivot in addition to the horizontal for the blade connection. This improvement was the means of decreasing stresses in the blades and reducing vibration.

The blades are constructed with a single longitudinal spar acting as the main strength member. Transverse ribs are fastened to the spars, the nose covered with plywood or sheet metal, and a trailing edge metal strip used to complete the skeleton. The framework is covered with fabric. It is important that the blade surface be free from transverse ridges or variations in contour because at certain positions during each revolution the airflow strikes the blade at a considerable angle.

At all times during flight the blades rotate freely by virtue of their motion through the air, whether the machine is flying forward at high speed or settling with power off. The rotor is designed for its most efficient rotational speed, determined by the ratio of blade tip rotational speed to maximum forward speed of the machine. Throughout all speeds and attitudes this rotational speed remains practically constant although it will be indicated later how the fixed wings coöperate with the rotor in this respect.

As the horizontal speed of the Autogiro increases the amplitude of flapping (vertical movement of each blade on its horizontal pivot) also increases. The advancing blade has a velocity equal to the sum of its rotational speed and the speed of flight; the retreating blade's velocity is the difference of rotational and forward speed. The advancing blade rises as it moves forward while the retreating blade falls. This flapping movement with its effective incidence change prevents undue variation in the lift of a blade during each revolution.

To start the rotor of early machines it was necessary to taxi around the flying field until the rotor revolutions became sufficient for take-off. Starting the rotor in this manner on a calm day required considerable time and skill. Then the biplane tail starter was used by which the slipstream was deflected through the rotor disc by placing the large horizontal tail surfaces at an angle. This method could not be depended upon to bring the rotor up to flight speed prior to take-off. In addition the excessive tail surfaces added considerable drag which was detrimental to the Autogiro's performance. The mechanical starter was, therefore, developed to give faster and more positive rotor starting. A manually-operated disc clutch transmits a small part of the engine power to a shaft, which drives the rotor through the medium of a pinion and ring gear. A simple overrunning clutch device is also used so that the rotor can freely overrun the engine at any time the engine speed should fall below the corresponding rotor speed. The rotor revolves at approximately 125 r.p.m. during flight so that the starter reduction gearing has about a 14 to 1 ratio. The ring gear is usually mounted on the rotor brake drum, an internal expanding brake being used to stop the rotor after landing. With the mechanism of present Autogiro, the rotor may be brought up to take-off speed or stopped after landing in less than thirty seconds.

The operation of starting the rotor for take-offs is simple. With engine idling the operator engages the clutch which starts the rotor slowly rotating. By opening the throttle gradually the rotor revolutions increase correspondingly. When the rotor tachometer indicates sufficient

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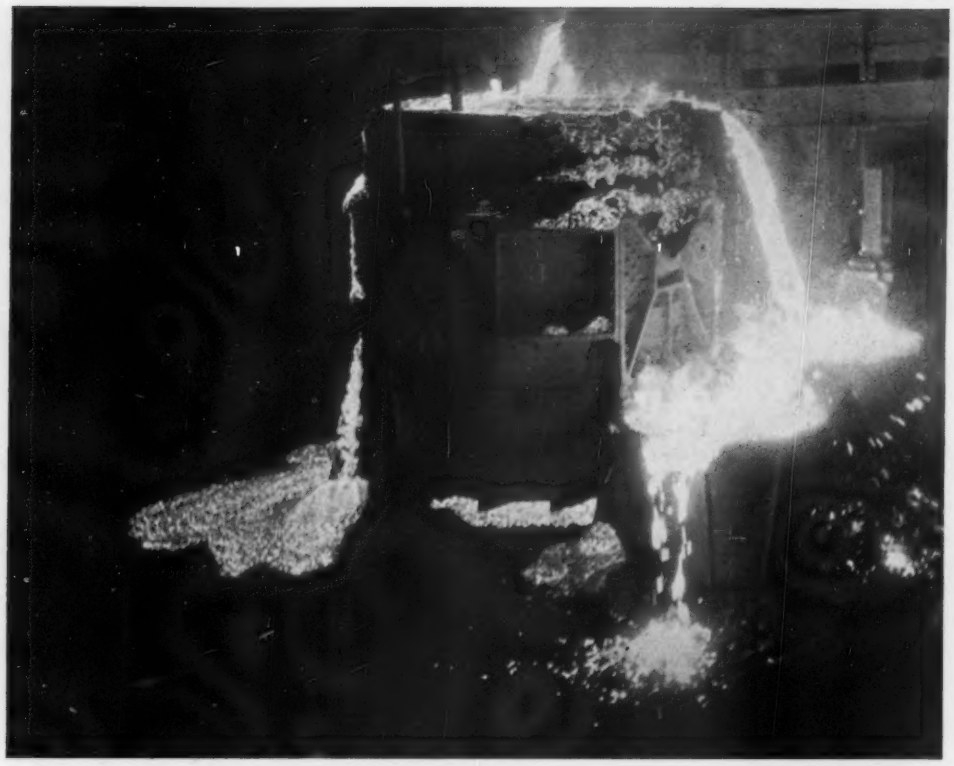
An autogiro in flight



New Ideas on

AN OLD ENGINEERING PROBLEM

IN the first installment of this article we examined the relation between the engineer and labor in its broader aspects. Now we must examine more closely the particular problems which the engineer faces in his dealings with workingmen. Most labor trouble arises when the worker is thwarted in his struggle for three prized possessions: justice, status, and opportunity. In most cases the wage problem is beyond the control of the practicing engineer, but the status of the worker, just treatment in disputes, and the opportunity for advancement are closely bound up in the engineer-labor relation.

First we come to the subject of status. By status I suppose we mean the preservation of a man's sense of dignity and self-importance. If this sense of self-importance is violated in any one of us, we develop an inferiority complex and this is particularly true of the workman who, because of the background of labor with its roots in slavery, is particularly susceptible to developing this sort of a complex. In colloquial language, he is "touchy," just as anyone who has unconscious feelings of an inferior background. This is the reason it is so important that young engineers have both an intellectual understanding of this background and also a very practical everyday knowledge of how to make your daily contact with the laboring man. Of course, just as with salesmanship, this problem of contact is an art, not a science.

For example, one of the leading architects in New York wrote me the other day of how he gets the confidence of the men working under him by asking the advice of some of the boss workmen and thus making them realize that he had a keen appreciation and recognition of their craftsmanship. Of course, when we come to this sort of problem it is a question of developing the art and not the science of contact. There is a nice balance to be maintained between preserving the workman's self-respect and not getting him too conceited. It is needless to say that a patronizing attitude must be avoided. Of course, it is well to realize that, though there is a certain general principle in the handling of human beings, each group requires a different approach. For example, we have plants with Mexicans in Arizona and with hill billies in Tennessee — and though the general principles are the same at both plants, there are certain differences in adjustment of those methods in each case.

The matter of personal approach is as important as the matter of developing a personal manner towards workmen. In this country a definite technique has been developed for both these purposes in the so-called works councils or employee representation. In addition you should know about some of the devices which have been developed for group contact and assuring status to the worker.

These vary from informal committees, to which a manager explains his plans, and committees which have purely advisory functions, to committees to which it has been attempted to give definite powers. I am one of those who have always regarded the function of the works council to be entirely advisory and consultative, its main purpose being to give the workers a feeling that they, the workers, have been consulted. Generally, it is well to achieve results through enlisting the coöperation of those in the organization rather than by autocratic orders. For example, in one of my establishments

Technology Review

—Labor Control

Part II:
INDUSTRIAL DIPLOMACY

By SAMUEL A. LEWISOHN
Chairman of the Board
American Management Association

the manager was interested in getting the men to pay more attention to the principle of "safety-first." Instead of relying entirely upon set rules, he found the most effective result was secured by having the whistle blow every day there was no accident. The men became keenly interested, listened each day for the whistle to blow and were very much disappointed when it did not. As a result, the accident rate dropped perceptibly. This is in accord with the tendency in America to invoke the game spirit — a very useful "non-financial incentive." In some factories this spirit is utilized by forming teams to compete against each other in making records in securing certain types of results.

Then we come to the desire of the workmen for opportunity. Workmen who are energetic desire a successful career. In America with our tradition of "Jack of all Trades," with our idea that every bright young man can adjust himself to almost any technique, we have probably gone further than any other country in trying to make use of promising material from the ranks. Of course, the proportion of workers who really seek advancement is much smaller than is commonly realized. It has been estimated to be not more than five per cent. But employers have found it very worth while to spend time and effort on systems of training and methods of awarding promotion to the able man. The success of our industrial system is largely dependent upon the training and advancement of the more ambitious minority of workers.

For example, there has been established in practically all the more forward-looking companies in America a Personnel Department. It is an absolute essential in large organizations to make certain that employees are handled with courtesy and given considerable attention and their "day in court." It is a means of making certain that each employee secures the opportunity of being transferred to a more promising position in another department if he is ambitious.

But, of course, it was the able manager who often found it impossible to give time to these matters. Thus injustice was often done to the workman because of inadequate provision for the specialization of this function. This was a case of lack of proper technique causing failure in providing such abstractions as justice, status and opportunity. I have been much impressed by plants under my own observation by the ease and informality with which transfers were made for ambitious workmen by a properly organized personnel department. Such a department ensures concrete justice by affording the worker a means of having his complaint heard with the minimum delay, and by taking the right of "firing" as well as the right of hiring from the harsh, unjust foreman. There have been some misgivings as to whether discipline might not be impaired by such a system, and yet to my personal knowledge it has worked out successfully in many plants where it was previously thought impossible. Of course, in most places, such problems are not settled in a juridical fashion as matters of right or wrong, but as matters of adjustment. Often, of course, men who cannot get along with one foreman will be transferred to another foreman with whom they may be sympathetic, and the whole trend is to avoid turning the factory into a courthouse.

(Continued on page 98)

The TECH ENGINEERING NEWS

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EDITORIALS

1936—Look Before You Leap

This editorial is addressed to the members of the class of 1936. Three years from now, you will be entering your senior year. Your name as a Tech man will have been made, for better or worse. Your success and efficiency as a senior will depend almost entirely on what you have accomplished during the first three years. And your accomplishments during those three years depend on the decisions you make now, today, in 1932. Now is the time for the look before you leap.

In every class there is a certain group which enters into the Activities of the Institute wholeheartedly and without urging. From this group will come most of the leaders of the class. But not all of them. There are also men whose ability and serious purpose warns them that classroom work must come first. That very ability and purpose which fits them for leadership prevents them from taking advantage of their opportunities. They must be convinced that work on an Activity is worthwhile. Theirs is a well-considered look before leaping. If they decide to enter Activity life, they invariably go to the top. If they do not, their talent is wasted, and the opportunity for trained leadership is gone.

It remains for the Activities to convince this group of able but cautious potential leaders that the leap is worth taking. For the most part the Activities do not have a hard job doing so.

So, to you men who are interested in improving yourselves but not sure of the way in which to do it, our word is this: take the initial step of establishing contact with an Activity. A week or two of association with the activity group will convince you that it is worthwhile.

Many of you will find that the TECH ENGINEERING NEWS appeals to you as a live, progressive activity. To you we extend welcome, and the assurance that you will find the work and associations of the T. E. N. staff worthy of its high reputation in the college publishing world.

Master Workmen

As time goes by it is no longer strange to find an engineer acquainted with things dramatic and artistic. Many of us may not be fully cognizant of the painstaking effort involved in great work, however.

Eugene O'Neill first jotted down notes for the drama "Mourning Becomes Electra" in the spring of 1926. His recently published diary of the progress of the play shows how he gradually assembled his ideas, fragment by fragment, whether on the Arabian Sea en route to China, or spending a peaceful winter in France. There is the conscious effort of the master craftsman to work only in the purest gold: Mr. O'Neill reveals how exhaustive was his search for the fine metals, how difficult it was to discard the dross. The finished play was turned over to the publishers only in September, 1931. More than five years had flown by since the conception of his particular Greek trilogy had occurred to the playwright.

Enterprises of this sort are difficult in the fast-moving twentieth century; but it is evident how valuable deliberate craftsmanship can be. The medieval glass-blowers and stainers showed so sturdy a fidelity to their task that today many of their secrets are interred with their bones, and the products of their skill leave us little but envy. We who are to be engineers and executives might well remember such examples of crea-

tive faith. Honorably to labor for the highest should be our ideal.

Karl Taylor Compton

Mark Antony's funeral address pointed out the homely truth that a man is never thoroughly appreciated until he is buried. By way of a denial of this statement we dedicate a few lines to our illustrious president, Dr. Karl Taylor Compton.

We all love stories of success. The story of a boy who came from a small mid-western town, the son of a college professor and his wife, is unusual in that this particular son has the happy reputation of a man with unnumbered friends and no enemies. His education in Physics was sound; yet he did not devote himself exclusively to studies but took part in athletics and the social life of Wooster College.

Since then, first in the field of his chosen work, Physics, and next in the wider responsibilities of administration, his record is well known. He has carried his honors with modesty, his defeats with good nature. His investigations have been conducted with the genius which pays attention to every detail. We are proud to be enrolled under a man who so unmistakably bears the stamp of greatness.

Nesmith Photo from The Magazine of Wall Street

New York Financial District Viewed from East River

The Pipes O' Carnegie

To those of us who were so fortunate as to hear them this summer, the concerts of Dr. Harry Emerson Fosdick and Mr. Simon on one of Andrew Carnegie's organs were a delight. Said *The New York Times:* "It is symbolic of something that may be done the country over. If all the pipes o' Carnegie could be set playing, they would give us a bit more spirit and courage in these vexing times."

The engineering student particularly seems in need of such relaxation. He has come to the Institute with a goal in view and a definite purpose in life. But he, like every other human being, needs diversion. Charles Darwin at the end of his long and fruitful life is known to have remarked that his one regret was his utter concentration on his subject. So intense had been his devotion to the origin of the species that his capacity for beauty in other realms, music or art or poetry, was atrophied.

At Technology there is an excellent organization of Musical Clubs, a glee club, a number of orchestras, a banjo club, and the R. O. T. C. band. From the midnight oil and the precise measurements of the laboratory, we can well afford a few hours a week to the appreciation of good music.

Reading for Thought

There is a small red book, modestly slim, by that liberal ecclesiastic, Abbé Ernest Dimnet, which might well be in every library. It is entitled "The Art of Thinking." Much or little as we know or fancy we know the ideas of this book are like high-powered binoculars for our minds.

One of the principal aids to clear thought is good reading. If we read for pleasure, as we should, we will find that those hum-drum classics which we so heartily despised in the grade schools are really the garnishments of a literary feast. We suspect that not one of us can resist the adventures of Jim Hawkins in "Treasure Island," or, lady-like as we may consider poetry, scorn the battle of *Sohrab and Rustum*. A good writer is hardly ever obvious. We must follow his thought "up the rushy valley, down the misty glen" until he reaches the lofty summit for which he aims.

If travel broadens, the reading of fine authors opens the mind to vistas of pure intellectual pleasure. And we must not read unprepared. When we find some particularly fine passage, we must note it down at once. Beauty, once glimpsed, should not be relinquished for one instant. The simple habit of keeping a red pencil handy is an aid to greatness in thought. Far better, and not more difficult after the first stride, write down in your private notebook the choicest thoughts which linger after your reading. You will be surprised by the change in your attitude toward, and appreciation of, books.

Determinism?

The advance of science is at once a process of generalization and specialization. The more general a law or principle is, the more specific applications it will embrace. As time goes on, the laws of science become more and more general, and hence more and more comprehensive. The phenomena of magnetism, electricity, light, and gravitation, once considered absolutely separate and unrelated, have now been combined into one branch of physics.

The separate sciences are becoming more closely knit together, and ultimately will *all* be expressible in terms of one science. For example, the properties of elements are functions of the mass, position, etc., of their elections; hence, given sufficient data about the elections of an element, all its physical and chemical properties will be determined thereby.

If fate is inexorable, why struggle? Because we are driven forward by the indefinable force of ambition, faith in ourselves, and the striving toward our ideals. Although the idea of determinism is inconsistent with the old, anthropomorphic view of religion, might we not consider this continual striving for the best as a kind of religion in itself, in which our faith is in ourselves and our ideals, despite all fatalism?

ENGINEERING DIGEST

Condensations of outstanding articles in the trade and scientific journals, published by special permission

Sperryscope

The High-Intensity Arc is the brightest artificial light source in existence

The High-Intensity Arc

By P. R. Bassett

Condensed from The Sperryscope, *July, 1932*

LIGHT projection and the electric arc have always been closely associated. The reason for this is apparent. Projection involves two elements — a light source and an optical system. Since the optical system has a definite focal point, the source must have its light output concentrated in the vicinity of the focus; this requires a source of high intrinsic brilliancy.

Of the various types of light emission, incandescence, the radiation of hot solids, gives the greatest brilliancies. When direct current passes between two carbon electrodes, part of the surface — known because of its shape as the "crater" — of the positive electrode is heated to incandescence at about 3,700 degrees C., the volatilizing point of carbon. At this temperature it emits light of a brilliancy of 170 candle power per square millimeter, which was over four times that of the next brightest source until the high-intensity arc was introduced.

The high-intensity arc is more than an improved carbon arc. It is a new type of arc, using as the light source a material never previously employed, and giving a brilliancy exceeding that of the carbon arc by over 300 per cent. In order to understand its action, however, it is essential first to study that of the older type.

In the ordinary carbon arc there is a tendency for material from each electrode to travel over to the other. For a current of 100 amperes, the flow of material from both carbons is intermingled and extends across the entire gap in both directions, as shown by the uniform coloring of the flame in the sketch. As the current is increased, the flame from the negative carbon grows stronger — so strong that it beats back the ions which are travelling from the positive electrode toward the negative. In the 150 ampere arc, the negative flame blows the positive ions back like smoke from a chimney.

When certain chemicals are used to impregnate the core of the positive carbon, and the arc is run at a heavy current density, a high-intensity discharge is produced which behaves quite unlike any other form of arc. The positive core gives off a very brilliant blue white flame which, when properly controlled, has a brilliancy of 500 to 1,000 candle power per square millimeter. By operating under proper conditions, the positive carbon is made to burn a deep crater in its end. This crater forms a protective housing for the brilliant high-intensity flame, and the negative flame acts as the cover which holds the high-intensity kernel in its crater.

In this type of arc, the positive carbon is impregnated with such chemicals as cerium fluoride. At the high temperature of the crater, these compounds react with the carbon to form carbides, colloidal particles of which form the brilliant flame in the crater at a temperature of about 5,000 degrees C. As soon as the carbides come in contact with air, they burn. Thus the source of light is a compound created only at the instant it is needed in the crater and destroyed again the instant it leaves the crater.

Electric Locomotives for the Pennsylvania

By J. V. B. Duer

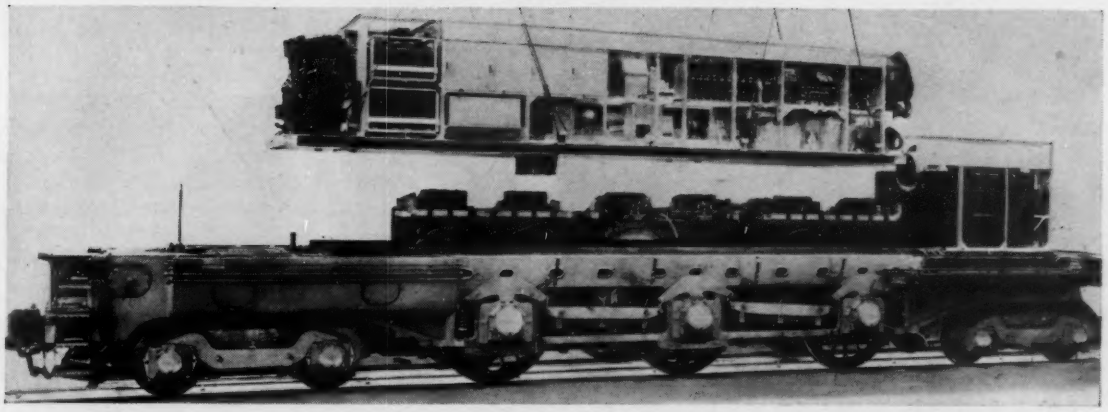
Condensed from Electrical Engineering, *July, 1932*

WHEN the electrified New York-Washington line of the Pennsylvania Railroad is put into operation, a fleet of locomotives representing the last word in electric motive power will enter passenger and freight duty. They are of three types, designed for light and heavy duty passenger service and for freight service. At the same time, interchangeability of parts is carried to such a degree that it would be almost possible to build any one of them from a given supply of parts. The basic driving unit is a 625 horsepower alternating current single phase commutating motor, and is used in practically the same form in each of the three classes of locomotives.

The light duty passenger engine is mounted on two pairs of driving wheels, and is powered with four motor units, giving it a continuous load rating of 2,500 horse-

The new-type electric locomotive to be used on the Pennsylvania

Electrical Engineering



Electric locomotive during assembly

power. This is somewhat greater than the capacity of the "Atlantic" type of steam locomotive. The heavy duty passenger engine, with three pairs of driving wheels, six motor units, and a rating of 3,750 horsepower, has a greater capacity than the "Pacific" type. The freight locomotive, powered with four motor units geared to four pairs of driving wheels, is rated at 2,500 horsepower, a capacity somewhat greater than that of the "Mikado" steam freight hauler.

High speeds are attained by all three of the new locomotives. The heavy duty passenger engine has a maximum speed of 90 miles per hour, and the freight locomotive can make 54 miles per hour. Such speeds will allow ample margins over present requirements, and at the same time will permit increased operating speeds in the future.

Digging the World's Longest Tunnel

By SPENCER A. JONES

Condensed from The Excavating Engineer, *July, 1932*

TRY to imagine digging a tunnel 20 miles long and wider and higher than the average single-track railway tunnel! Then imagine that before you can start digging the tunnel you have to excavate shafts 14 to 17 feet in diameter down to 500 feet below sea level to reach the level where the tunnel is to be dug! If your mind has not been dazed by trying to visualize such a project, you have a picture of New York's huge new water tunnel, the longest in the world, now being completed far beneath the city.

New York City uses about one billion gallons of water daily. The Croton system partially supplies the Bronx and Manhattan; ground water plants partially supply Queens, Brooklyn and Richmond, but more than 60 per cent of all water comes from the great Catskill system which supplies water to all five boroughs.

Since 1917, when the Catskill water was first brought to New York, a single tunnel has been conveying it from the Hill View Reservoir in Yonkers, south under the Bronx and Manhattan Island, and under the East River from the southern part of Manhattan to Brooklyn. This tunnel, known as Tunnel No. 1, carrying the major portion of all New York's water, has been overtaxed for several years, but it has been neither shut down nor repaired since its completion. Any shut-down of this vital artery for an appreciable period would be disastrous; in fact a major catastrophe, particularly for Brooklyn.

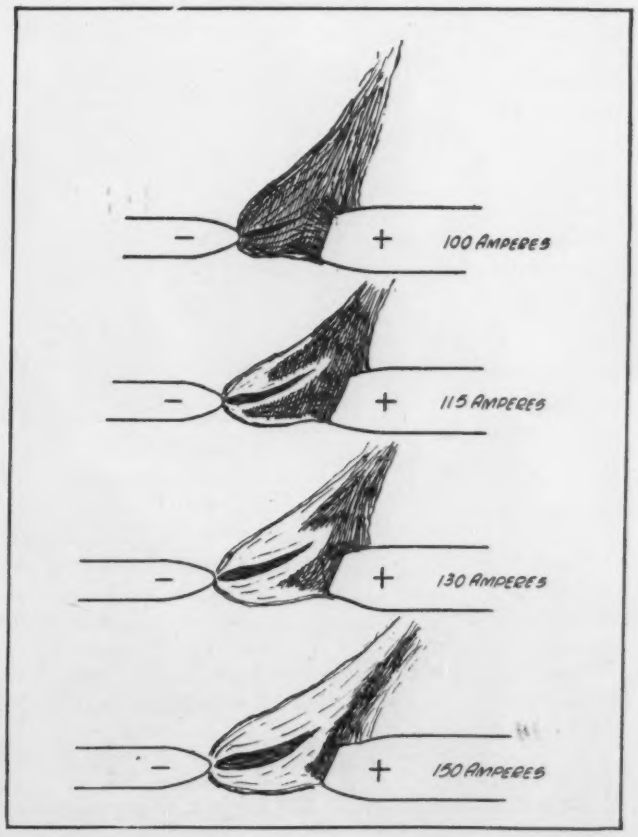
To reduce the load on Tunnel No. 1, to improve pressure conditions, to reduce fire hazards in every borough, and for prevention of damage should there be a necessity of shutting off Tunnel No. 1, the Board of Water Supply was authorized in 1927 to construct another tunnel from the Hill View Reservoir under Bronx, Queens and Brooklyn boroughs to a terminal shaft in South Brooklyn — a distance of 20 miles.

The new tunnel is called Tunnel No. 2 and it will be so connected with Tunnel No. 1 that water can be delivered through either or both. The pressure in the tunnels will be so great that the water they carry will rise 280 feet above sea level without the aid of pumps.

Tunnel No. 2 is a circular, concrete-lined pressure tunnel with a finished inside diameter of 17 feet and a nominal capacity of seven hundred million gallons daily. Through its entire length it is 500 feet or more below sea level and it passes through bedrock in an area and at a depth heretofore unexplored. When completed with all special equipment and permanent superstructures, its cost will be nearly $600 per linear foot, a total of about $60,000,000.

With work going on simultaneously at 17 widely separated shafts, the great problem is coördination of effort. Nevertheless, probably no other work of similar

(*Continued on page 100*)



Diagrammatic action of the High-Intensity Arc

RESEARCH IN REVIEW

Course I

Massachusetts Institute of Technology has settled into the ground from two to eight inches since 1916, Building 10 sinking the most. Studies of the settlement of buildings on clays, carried on jointly by Professor Gilboy and Mr. Buchanan, representing the American Society of Civil Engineers, have shown that this settlement checks closely with theoretical calculations.

How soils behave under various conditions of stress and strain is a question of vital importance to the builder of skyscrapers, dams, and bridges; hence the value of research being carried on by Dr. L. Jurgenson and by graduate students in Course I, on the problem of soil stress-strain relations.

Frost heaving of highways — the result of water being drawn up underneath by capillary attraction and freezing into an ever-growing layer of ice — has been the subject of extensive study at the Institute by Mr. Arthur Casagrande, a representative of the United States Bureau of Public Roads.

Strong currents in the Cape Cod Canal, caused by unequal, "out of step" tides in Cape Cod Bay and Buzzard's Bay, may be remedied in the near future by the construction of locks. The effect of such locks on the tidal currents has been studied in the M. I. T. River Hydraulics Laboratory, with the aid of a 40-foot concrete model of the Canal.

Engineering News-Record

Dnieprostroy Dam, Russia's Greatest

How fast does a flood wave travel down a river? This problem, of great importance when several hydro-electric plants are located along the same river, is being attacked experimentally by Mr. D. A. Holden, a Course I graduate. With electrical timing apparatus he has clocked waves of many sizes and shapes, rushing down a long flume.

Course II

Research continues on the subject of cavitation, a phenomenon caused by the formation of vapor bubbles in water and their subsequent compression at temperatures high enough to damage propellors, turbine blades, and other high-speed hydraulic devices. Under the direction of Dr. H. Peters, the huge cavitation apparatus at the south end of Building 3 is being improved by the installation and testing of new instruments.

Course III

Chilling metals to sub-Arctic temperatures has surprising effects upon their properties. Tests on many different materials at temperatures as low as —77 degrees C., obtained with frozen carbon dioxide, are being carried on by Mr. D. P. Dyer, Jr., a graduate in Course III. He has found that the tensile strength of stainless steel is actually doubled under this frigid treatment.

Course V

High-frequency radiation changes the proportions of oxygen, carbon monoxide and carbon dioxide which exist together in equilibrium. Mr. C. W. Orleman is investigating this effect with radiation at frequencies as high as 30,000,000 cycles per second. Mr. Louis Goldman is doing similar work with the nitrogen-hydrogen-ammonia equilibrium.

Course VI

The Differential Analyzer, Course VI's mechanical mathematician, has learned a new trick. It now prints its answers on a roll of paper, in figures, besides giving them in graphical form. Compressed air pistons stamp the paper against numbered disks much like those in a speedometer, revolving at speeds up to 600 r.p.m.; yet the figures, printed in 1/10,000 of a second, are perfectly sharp.

Radio listeners have never enjoyed the full volume range of many programs, because the telephone line from the studio to the transmitting station cannot carry signals that are either too weak or too strong. Mr. H. H. Beizer, a Course VI graduate, has solved the problem with a circuit which narrows the program's volume range before putting it on the wire line, and expands it back again at the broadcasting station.

(*Continued on page 100*)

THREE ADVENTURES

(*Continued from page 86*)

known integral numbers of protons and electrons, their masses are variously less than the aggregate mass of the constituent protons and electrons. The whole weighs less than the sum of its parts. Thus, for example, we calculate from the atomic weights of hydrogen and helium that, if four grams of hydrogen could be transformed into helium, there would be liberated enough energy to evaporate a thousand tons of water! It is from such considerations that we have a clue as to the possible sources of subatomic energy, and their amounts.

Equation (2) states that, if energy E is transformed into aether waves, the wave frequency ν is proportional to E, the constant $h=6.55\ (10)^{-27}$ being the famous Planck's constant, which enters into all equations of the "Quantum Theory." Thus, if the frequency ν of any radiation is measured, we can at once calculate the atomic energy change which produced it, and then, if we wish, we can compute the accompanying change of mass by Eq. (1). Or, conversely, these two equations enable us to calculate the frequency of radiation to be expected by any given atomic energy change, or mass change. This relation is of the greatest significance in disclosing the atomic processes which give rise to heat radiation, light, x-rays, gamma rays, and will furnish the key to the origin of cosmic rays, if they are aether radiations as Millikan believes.

High Voltage

Within the past four or five years the foregoing considerations have given a great impetus to the development of high voltage sources. German physicists have harnessed lightning in the Alps. Tuve of the Carnegie Institution of Washington has built an oil-immersed Tesla coil yielding three million volts. Lawrence at the University of California has developed an ingenious method of getting million-volt electrons or protons by successive applications of much lower voltages. Most powerful and convenient of all appear to be the generators being constructed by Van de Graaff in the M. I. T. laboratories in Cambridge and Round Hill, and a modification by Barton at Princeton. These are distinct from the transformer or surge generating devices which commercial laboratories have been using for study of insulation breakdown and lightning protection.

The significance of these devices lies in the fact that with them we should be able to accelerate electrons, protons and ions to have kinetic energies comparable with those of the alpha and beta particles from radium or the products of ionization by cosmic rays. We should be able to produce x-rays of as short wavelength as gamma rays or even cosmic rays, for Eq. (2) tells us just what to expect from a particle of charge e accelerated by a voltage V. We should be able to reverse or to accelerate the spontaneous processes of atomic transmutation and to produce artificial processes at will. And we should be able to do these things on a vastly larger scale than any transmutation processes thus far observed. This is the goal. What unknown difficulties are yet in the way, or how significant the final results will be are still in the future. Never in the history of science has there been an outlook so pregnant with reasonable possibilities.

▣ ▣ ▣

TRANSPORTATION

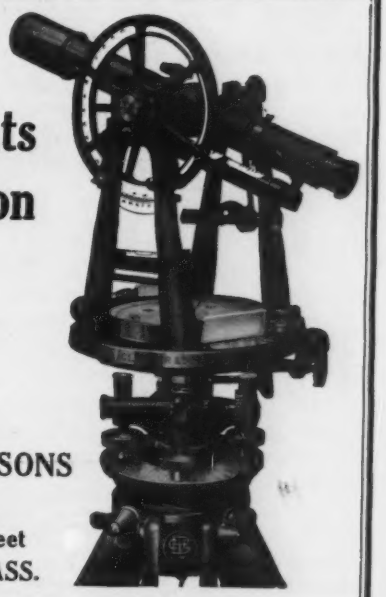
(*Continued from page 87*)

was carried out on July 17, 1929, by Dr. Goddard at Worcester, Massachusetts. This innovation, while entirely satisfactory from one point of view, immediately led to a difficulty in another direction. Liquid oxygen boils at −182 degrees C. and the temperature within the nearby combustion chamber rivalled that of an oxy-acetylene blow-torch. To overcome this, since it is almost impossible to omit the liquid oxygen and since space would not permit the substitution of gaseous oxygen, the experimenters had either to increase considerably the size of the rocket, or to discover a material with great tensile strength which practically was a non-conductor of heat. In the end a compromise was effected, and both methods were utilized. At the present time, workers in Germany have successfully constructed a rocket motor of duralumin which weighs only half a pound and is about the size of an egg. The rocket has a lift of over thirty pounds and is capable of hurtling a fifteen-pound rocket a distance of fifty miles in one minute.

There are several reasons why the rocket is not yet feasible for short flights, the greatest being that the rocket is most efficient at high velocities, and on short flights it does not attain them. At velocities of over 600 miles an hour or 880 feet per second, the rocket has an efficiency of around 60 per cent, making it the most efficient heat engine known. Modern rockets are able to develop a velocity of from 7,000 to 8,000 feet per second. It is impossible to make short flights and attain this speed. Consequently until some device has been found which will harness this power and enable it to be utilized to better advantage, practical travel with the rocket would be dangerous, to say the least. Yet despite this fact, the rocket could be used for the carrying of trans oceanic mail and other matter. But here, since there can be no pilot within the rocket, rises the difficulty of controlling its landing. This question is as yet unsolved, although several means have been suggested. The most feasible of these would seem to be the utilization of a huge photo-electric "eye," located in the nose of the ship. At the end of its flight, the accuracy of which can be kept within an area of fifty miles, the

(*Continued on page 99*)

Standard Instruments of Precision



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AUTOGIRO

(*Continued from page 89*)

r.p.m., the clutch is disengaged and the throttle opened wide for take-off. Brakes on the landing gear wheels hold the machine stationary while the rotor is started.

In Autogiro design the longitudinal position of the center of gravity of the machine relative to the rotor must be held within definite limits. This problem is more acute than the location of wing and center of gravity in an airplane. In an Autogiro there is the need of a considerable degree of static or pendular balance, in contrast with the dynamic balance of an airplane, which, due to its speed, can obtain the correct trim by a change in stabilizer setting. However, during steep descent and slow speed flight of an Autogiro, the stabilizer and elevator are capable of correcting only a limited movement of the center of gravity from ideal balance position. For this reason, careful consideration must be given to the location of loads.

The rotor is built on the fuselage in a position so that in steep descent the rotor thrust passes very near and slightly behind the center of gravity of the craft. Should the engine power fail at such a time the Autogiro is then correctly balanced so that if the operator desires he can use his controls to cause the machine to glide forward even though the effectiveness of the controls happened to be a minimum at the time of engine failure.

A factor which influences the Autogiro's longitudinal stability is the location of the propeller thrust with respect to the machine's center of gravity. On account of the position of the rotor, the center of gravity of an Autogiro is relatively higher than other aircraft. It is important to have the propeller thrust pass close to the center of gravity because, at the low flight speeds of which the Autogiro is capable, there is insufficient elevator control to counteract the large moment due to sudden throttle opening. By tilting the engine and propeller, the propulsive thrust can be properly located. This is also a decided benefit at high speed flight since, if the propeller thrust falls below the center of gravity, there is an additional moment in the same direction as the moment of the rotor thrust resulting in longitudinal instability.

Although the Autogiro has a high degree of inherent pendular stability, it is necessary to definitely design the fuselage, vertical tail surfaces and fixed wing proportions to provide automatic lateral stability which will return the ship to a level keel from a side slip condition. Because of the high center of gravity position, the preponderance of fuselage side area is below the center of gravity, giving an upsetting moment in a side slip. To provide the necessary righting moment upturned wing tips are generally used. Reference to Figure 4 will clearly show the effect of the upturned tips. Any tendency for the ship to move sideways through the air immediately provides a lateral force on the tip surface which passes at a considerable distance above the center of gravity, thus giving a strong righting moment. The upturned tips are designed with correct area to also give automatic banking qualities in a turn. When rudder alone is used the tendency to skid produces sufficient banking force to make a good turn. Upon release of the rudder control, the ship will return to level position. Normal ailerons give additional maneuverability and control.

Good directional stability can usually be secured by having sufficient vertical area aft of the center of gravity to give weathercock action. However, the directional qualities may be impaired by improper design and location of upturned tips.

Even though the Autogiro is a comparatively new contrivance, the engineering phases have developed rapidly, partly because of the airplane background which supplied efficient power plants and light practical structures. Engineering methods for normal type Autogiros are fairly well standardized somewhat along the lines of airplane design practice. In the development of these Autogiro engineering methods, a number of new and interesting problems were involved. While several of the main components of an Autogiro, such as fuselage, fixed wings and landing gear, closely resemble similar airplane units, nevertheless the design of these parts is closely interrelated with Autogiro characteristics.

The pylon structure supporting the rotative system is greatly overstrength for all flying conditions. The criterion of design for this unit is its strength and rigidity during rotor starting and also during severe handling on the ground when a blade may bottom heavily on its supporting cable while taxiing. The reactive starting torque of the mechanical starter imposes large torsional and bending loads in the pylon legs. The chief flight stresses in the pylon are tensile combined with some bending.

An Autogiro fuselage is analysed in a manner similar to an airplane except that some sections must also be investigated for the starting and taxiing conditions which design the pylon.

The landing gear of an Autogiro is built with very widely spaced wheels in order to prevent tipping over sideways when landing with drift. Drift is more noticeable in an Autogiro than an airplane. At the Autogiro's low forward speed, a small amount of side movement will form a relatively important part of the resultant landing velocity. The landing gear is also provided with shock absorbers having a travel about twice as long as the normal airplane. Shocks of steep landings can readily be cushioned. Ground maneuverability is obtained as in other aircraft by the use of individual wheel brakes for turning, steering, etc. A tail skid or wheel of normal type is used.

Ordinary stick and rudder flight controls are used. The rotor controls consist of a brake and a starter lever, operated only when the machine is on the ground.

The ease of learning to fly an Autogiro and its remarkable safety and other qualities make it the ideal aircraft for the private owner or business man. Most Autogiros have been designed with this purpose in view. It is especially adaptable, however, for many new and practical commercial uses which previously could not be satisfactorily performed by aircraft. As the demand for Autogiros for specific purposes grows, they can readily be designed to satisfy particular requirements desired.

ENGINEERING PROBLEM

(*Continued from page 91*)

Other items in a properly organized personnel program include training and medical departments, employment department and foremen training conferences. I have gone into all these matters of detail to indicate to you how important it is that men who by any chance may become industrial managers, have a background both in labor economics and labor administration. Any educated engineer should have a thorough grasp of both the background and the technique of the problem as a matter of course.

It is maintained that they are over-specialized not only from the point of view of their industrial usefulness but also as social human beings. Well, here is the opportunity for adding to your *repertoire* a study of this subject of labor relations that will fulfill two purposes. It

will give you in the first place an equipment of practical utilitarian value. For this matter of properly handling labor relations is no idle sentimental gesture, but part of the day's work. It will also have an indirect benefit to you in broadening your intellectual horizon. You can have your cake and eat it too. Without any deviation from your objective of securing a professional equipment you have here a subject that will assist to develop your imagination and intuitive qualities. For your entire training is to confine yourself to fields which only permit of *precise* thinking. You are apt to feel a little at a loss in fields where the outlines are slightly vague. And yet aside from this problem of labor administration it is important even from an economic point of view that you develop imagination. The really big engineer in mining or industrial fields must develop his imagination in order to visualize the development of a mining property or the building of a plant.

I have emphasized the practical advantages of a well-equipped engineer in having a grasp of this problem. May I suggest another consideration? One of the criticisms that have been levelled against engineers is that they understand inanimate matter and have no knowledge of other subjects. The engineer often cannot rely purely on precise yardsticks but must visualize broadly. He must remember there are many fields where exact measurements are impossible. A study of labor relations will help you to develop these qualities. The problem is a fascinating one from an intellectual point of view. It has also great significance from a social point of view. Here is a chance to make an important contribution to our industrial methods, an opportunity to take part in the continuous adventure to improve conditions.

TRANSPORTATION

(*Continued from page 97*)

photo-electric "eye" would take control, and, guided by a great beam of rays from the landing field, pilot the rocket to that spot, where the required landing facilities would be waiting.

Another feature to aid such travel has recently been developed by Dr. Goddard. The apparatus consists of two turbines, mounted behind the rocket on axes parallel to the gas flow. Where small velocities are required, the operator within the rocket swings these into the gas stream, where they serve as propellers and drive the ship forward in that manner. For higher velocities, the wheels are shifted to one side, and the ship is propelled as a rocket. The movement of the turbines is variable, and may be adjusted to utilize all, part, or none, of the gas flow.

As there are difficulties in the way of transoceanic travel, so there are difficulties in the path which leads to interplanetary travel, the thought of which has long stirred the world's imagination. Yet these difficulties are by no means insurmountable. The average distance from the earth to the moon is 238,833 miles. At present attainable speeds of around 8,000 feet per second, this entire distance could be traversed in a little under 44 hours. In this calculation we have neglected the facts that the moon comes much closer than the value given; that in the larger rocket utilized for such a flight it would be possible to use a more powerful fuel which would give a greater velocity; and that the moon's gravitational pull, which is approximately one-sixth that of the earth, would be felt when the rocket was yet a considerable distance from the moon. From that point on, the rocket would be merely falling onto the moon, because of the weight of the rocket. While some fuel would necessarily have to be carried to provide braking power, yet the amount required for that remaining distance would be relatively small.

The other difficulties of such a flight are almost of no importance. The fact that a vacuum must be crossed causes no worry, for a rocket travels just as well in vacuo as in ordinary atmosphere. In fact, experiments have shown that an increase in efficiency of 22 per cent is realized by its travelling in a vacuum. The rocket could be made of sufficient length to provide room for the travellers, and to separate them from the terrific heat of the motor. Oxygen could easily be carried for breathing purposes. Light-weight shock absorbers could ease the landing force. In fact, the difficulties seem easily overcome. However, it is clearly recognized that the dangers would be innumerable, at least during the early flights of experimentation. Yet sometime, the spirit of adventure and exploration, and the search after knowledge which led Magellan around the world, Drake across uncharted seas, Livingstone into darkest Africa, Peary to the North Pole, and Amundsen to the South Pole, will cause explorers to set out into the wilderness of space.

SOLID CO_2

(*Continued from page 88*)

there is a decided saving if the inside walls are lined with a fibrous material, which is usually a poor heat conductor.

Since 1925, when Dry Ice was first used commercially, the increase in consumption has been phenomenal. In 1931 approximately 70,000 tons were used. This remarkable increase in the use can be attributed almost entirely to the demand of the ice cream trade for a clean, convenient and economical refrigerant, for the transportation and distribution of its highly perishable product. At the present time, the ice cream trade is using 90 per cent of the Dry Ice sold.

During the past years, this refrigerant has cost the trade from 2 to 10 cents per pound, depending upon the amount used and the geographical location of the user in regard to the manufacturing plant. There are several additional markets which will be fully developed only after a dependable and stable supply of the refrig-

(*Continued on next page*)

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SOLID CO_2

(*Continued from page 99*)

erant is assured, and after the manufacturing or distributing centers are located throughout the country so as to make it universally obtainable at a reasonable price.

Dry Ice as a Refrigerant

Experiments with the preservation of perishable food products soon demonstrated that selective and positive temperature control is necessary. The duty of any temperature control in connection with perishables, is to preserve the product with a minimum consumption of power or refrigerant. In the use of Dry Ice, positive temperature control means maintaining a uniform maximum temperature — the maximum temperature demanded by the product being refrigerated.

The problem of using Dry Ice to produce a refrigerating effect then resolves itself into the following requirements:

1. A system which is free from mechanical difficulties.
2. A control which will transmit the refrigerating effect when and in what quantities required.
3. A Dry Ice storage space which will hold a sufficient amount for an extended period and also protect the stored Dry Ice against excessive heat leakage losses.

Most of the methods suggested can be classified as either direct or indirect. The indirect method is distinguished by the introduction of an intermediate heat carrying liquid or gas which can be regulated in its flow between the Dry Ice and refrigerated space to produce proper temperatures in the refrigerated space.

A typical example of the indirect method consists of an endless tube arranged in two interconnected coils, one substantially above the other so that a volatile liquid hermetically sealed inside the tube will drain by gravity from the higher coil to the lower coil. The upper coil is termed the condenser and the lower coil the evaporator.

When solid carbon dioxide is placed in close contact with the condenser, the chilling action condenses the gas evolved from the volatile liquid in the evaporator, which is at a higher temperature than the condenser, causing the liquid to boil freely as the gas passes off and into the condenser. As evaporation takes place, heat is absorbed by the evaporator, thus producing the refrigerating effect. The gas condensing in the upper coil drains back to the evaporator as a liquid, having given up its heat of condensation to sublimate the solid carbon dioxide. The volatile liquid, which is normally methyl chloride, thus acts as the heat conveyor between the refrigerated space and the solid carbon dioxide.

An adjustable thermostatic valve in the gas line between the top of the evaporator and the condenser absolutely controls the refrigerating effect of the evaporator. When this valve closes, gas is trapped in the evaporator, and as this volume of gas increases the entire charge of liquid is forced backwards out of the evaporator into the condenser. When refrigeration is again required, the valve opens, relieving the gas to the condenser and permitting the liquid to flow into the evaporator. As the action is entirely physical, every B.T.U. used to sublime the carbon dioxide is converted into useful refrigerating effect in the evaporator.

Future Possibilities of Dry Ice

The immediate forecast allots the major possibilities for further use of Dry Ice to the preservation and transportation of frozen and perishable foods. This market is yet to be cultivated but is within conservative vision. However, there are other uses which are yet in the visionary stage but bid for extensive quantities. A few examples of these are air conditioning, explosives and fire extinguishers. In addition to these, there will be a multitude of applications such as plastic surgery, laboratory experiments and source of power for pneumatic machinery.

Considering all of these rapid and positive advances of the Dry Ice Industry, it is very convincing to the engineer that Dry Ice has definitely become a part of our commercial life, and that it offers many possibilities to those wisely applying it to their problems.

RESEARCH IN REVIEW

(*Continued from page 96*)

Course VIII

"Now it's off, now it's on" — so operates the intermittent filament supply recently developed in the Physics Department for studying vacuum tube filament coatings. Current flows through the filament under test for 1/200 of a second; during the next 1/200, no filament current flows, and the desired measurements are made with the whole filament at one potential.

Mr. Nathan Rosen has computed the theoretical moment of inertia, dissociation energy, and fundamental vibration frequency of a normal hydrogen molecule, and checked his results with experimental values. The moment of inertia is indeed small, being about $5(10^{-41})$ gm.-cm^2.

Course XVI

Glider tests on a small motorless plane, launched by means of a long "slingshot" of shock cord, are being made on Coop Field by Lt. B. S. Kelsey. Motion pictures taken during each flight of the tiny plane, 16 feet in wing span, preserve information concerning stability which cannot be found from wind tunnel tests of models.

ENGINEERING DIGEST

(*Continued from page 95*)

kind has ever been carried on with greater speed or greater efficiency. At the present rate of progress, Tunnel No. 2 will be completed more than a year ahead of schedule.

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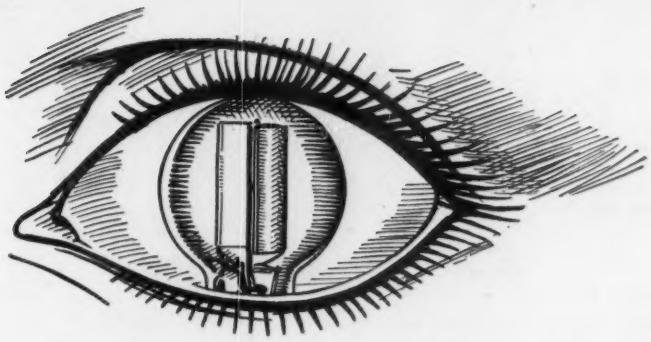


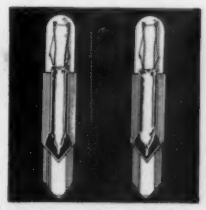
One eye that sees better than two

Heat coils act as tiny circuit breakers, protecting delicate and sensitive equipment from effects of stray currents.

Makers of telephone equipment cannot rely on their eyes in testing a certain type of coil used by the million in central offices. For greater accuracy they utilize the "electric eye" or photoelectric cell.

At Western Electric this uncanny piece of apparatus "stares" all day long without fatigue recording galvanometer readings. ¶ It forms a vital part of a machine for automatically separating perfect from imperfect coils. Its use is typical of the way this organization puts science to practical advantage. ¶ Here is no blind following of tradition. And yet new methods must prove themselves worthy—must be tested as carefully and as thoroughly as the telephones and telephone equipment manufactured for the Bell System.

One heat coil every second —tested by the "electric eye" at Western Electric.



The human eye can detect no difference between these switchboard lamps but the "electric eye" can and does.

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SINCE 1882 FOR THE BELL SYSTEM

Talking from the sky on a beam of light

THE huge U. S. Navy dirigible, Los Angeles, is roaring above the General Electric Research Laboratory at Schenectady. On board the airship, an almost invisible beam of light is aimed at a 24-inch mirror-target a half-mile below. The mirror, turning as it follows the dirigible's course, catches the slender beam. Voices transformed into electric impulses in the airship are carried to the mirror by light waves. A photo-electric cell picks up these waves and they are reconverted into sound, which is broadcast to the world by radio.

A "voice on the air," with a "voice from the air"—the official opening of radio station WGY's new 50-kw. transmitter is taking place. One millionth of a watt—generated from the blast of a police whistle in the dirigible—is transmitted to the ground on the beam of light and to a Thyratron tube. The tube magnifies the whistle energy 50,000,000,000,000 times to operate the switches that start the transmitter, five miles away.

(Insert) John Bellamy Taylor, General Electric research engineer, operating projecting apparatus

Receiving mirror on roof of General Electric Research Laboratory

Thus was "narrowcasting," a possible means of secret communication, recently demonstrated to Military and Naval experts by General Electric engineers. The future will demonstrate its commercial value. Electrical developments such as this are largely the accomplishments of college-trained engineers. They are leading the way to even greater progress in the electrical industry and are helping to maintain General Electric's leadership in this field.

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